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Indian Standard

CODE OF PRACTICE FOR INSTALLATION AND MAINTENANCE OF ROLLING BEARINGS

(Fourth Reprint MARCH 1986)

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INDIAN STANDARDS INSTITUTION
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Gr 6

June 1965

Indian Standard
CODE OF PRACTICE FOR INSTALLATION AND MAINTENANCE OF ROLLING BEARINGS

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Indian Standard

CODE OF PRACTICE FOR INSTALLATION AND MAINTENANCE OF ROLLING BEARINGS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 3 April 1965, after the draft finalized by the Bearings Sectional Committee had been approved by the Mechanical Engineering Division Council.

0.2 Ball and roller bearings, collectively known as rolling bearings, are being used almost on all modern machines. In order to have full use of these bearings, it is necessary that these are installed with care and proper attention is paid to preventive maintenance. This standard is intended to serve as a guide to the users for the proper use of ball and roller bearings.

1. SCOPE

1.1 This standard covers the preparation, fitting, maintenance, lubrication and repairs of rolling bearings.

2. TERMINOLOGY

2.1 For the definitions of terms used in this standard, reference may be made to IS : 2399-1964*.

3. PREPARATORY

3.1 All parts of the bearings, including the bearing seatings, shoulders, fillets, slots for withdrawing tackle, etc, shall be checked for size, form, and surface finish and all burrs removed. Shoulders shall be square with the shaft axis. The interiors of all housings shall be clean and free from scale and core sand. In case of doubt, an oil-resisting, non-flaking paint shall be applied (not on the bearing seatings) to cover up blowhole surfaces and thus bind loose particles which might otherwise become dislodged when the machine starts working.

3.2 Only non-fluffy rags shall be used for wiping the parts since fibres from cotton waste or other loose material can be as destructive as other forms of extraneous matter.

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*Glossary of terms relating to rolling bearings.

3.2.1 All parts shall be first thoroughly cleaned with a rag dipped in white spirit or benzine or any other non-corrosive cleansing fluid (not paraffin), and then finished off with a clean rag.

3.3 If felt washers form part of the sealing devices, these shall be soaked, before use, in a light mineral oil or hot vaseline until they are thoroughly impregnated. They shall not bind on the shaft as this may result in heating and scoring.

3.4 All tools including heating tanks if required for heating bearings, collars, etc, shall be conveniently arranged to enable shrink fits to be employed.

3.5 The bearings shall not be taken out of boxes or unwrapped until required for use, for they are apt to pick up dirt from benches or fine grit from atmosphere. The protective coating of special grease or oil shall not be removed unless special instructions to the contrary have been given by a responsible person, or the bearing has become dirty. If cleaning is necessary, the methods described in **7.5** should be adopted. Bearings shall never be kept on dirty benches. A clean piece of paper or other material shall be put under and over the bearings.

4. FITTING

4.0 The usual and convenient procedure for mounting rolling bearings is first to fit them on the shaft and then to place the housings in position. When, however, an outer ring has a tight fit in its housing and the inner ring a loose fit on the shaft, it is recommended that this procedure be reversed.

4.1 Shafts

4.1.1 With tight fits for cylindrical mating parts, considerable force may be necessary to drive an inner ring up to its locating shoulder. If pressure is applied to the outer ring while this is being done, severe permanent denting of the tracks by the rolling elements is likely to occur. Direct pressure against a thin inner-ring lip may cause fracture or, if the pressure comes on the cage, this may be badly distorted.

4.1.2 When the fit is not too tight a piece of hardwood or copper drift may be used as shown in Fig. 1. The end of the drift in contact with the

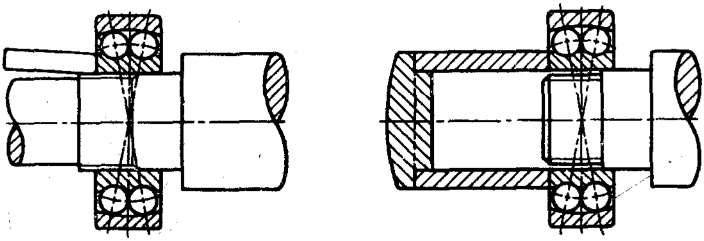


FIG. 1

inner ring shall be bevelled off to clear the periphery. When the rings have thin lips, light blows shall be given to the drift by a hammer, moving the drift round the ring taking care to see that no chips which break off the drift get into the bearing. Heavier blows may be given, when a mild-steel tube, of the right size with an end ~~cap,~~ is used provided the tube is kept parallel to the shaft axis.

4.1.2.1 An easy method of fitting an inner ring is to put the shaft under the ram of a hand screw mandrel press, using a tubular sleeve to transmit the pressure to the inner ring.

4.1.3 Where a fit proves to be tighter than specified, no attempt shall be made to reduce the diameter of the shaft by scraping or rubbing it with emery cloth or other similar material. Instead, the shaft may be corrected on a lathe or a grinding machine. If the fit be too slack, packing with strips of paper or tinfoil shall not be done, nor any attempt be made to raise the surface by a centre punch. If it is important to save the shaft, the seating may possibly be reduced a little, a bush shrunk on, and its outside then ground or turned to size. An alternative method is to have the seating enlarged by metal spraying or plating, and then finished to size by grinding.

4.1.4 The use of force for driving a ring on to a shaft can be avoided by heating the bearing in an oil-bath (*see* Fig. 2) to about 80°C maximum. By this means the ring is expanded so that it can be slipped easily into position against the locating shoulder. The ring shall be held axially against the shoulder until it cools; the shaft nut or some other suitable means being used for the purpose. Pure mineral oil or soluble oil may be used as heating medium, soluble oil being preferable since it is safer and less expensive, although some types produce an objectionable odour when

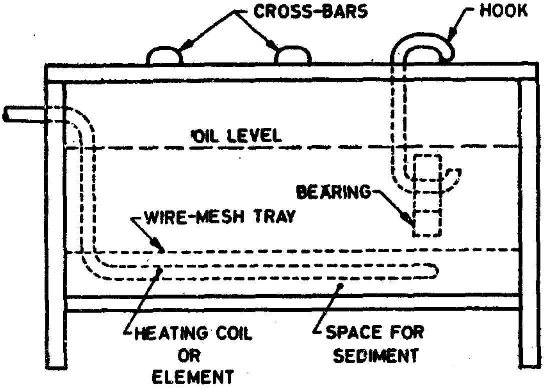


FIG. 2

heated. The wire netting tray shown in the illustration prevents the bearings from making contact with the bottom of the tank, and may also be used for supporting them while they are being heated. Hanging the bearings on hooks suspended from a top cross-bar prevents the necessity of probing about when removing them for fitting.

4.1.5 Bearings which have been heated in the manner described in **4.1.4** may be lifted out of the hot oil-bath by means of the scissor-tongs illustrated in Fig. 3. By gripping the outer ring in the manner shown, the operation of sliding the bearing into position on the shaft is facilitated. In order that scratching of the outer ring tracks and rolling elements or damage to the cage may be avoided, the claws shall only project inwards by a very small amount. An appliance of this kind is also useful for handling large and heavy bearings.

4.1.6 As soon as the bearing has cooled in position, the correct grade of grease or oil shall be applied forthwith to both the interior and the exterior surfaces. Unless preloading is intentional, in which case, the bearing may offer slight resistance to rotation, it shall rotate quite freely. Self-aligning bearing shall swivel easily in all directions. With roller bearings it is usually possible to check the diametric slackness after fitting by inserting feelers between the rolling elements and the outer ring track, lifting the outer ring meanwhile to take the weight off the feeler gauge. Attempts shall not be made to rotate the bearing while gauging the slackness, but the feeler shall be carefully slided over a roller. When tracks or rollers are convex or concave, misleading results are obtained unless the feeler passes through the narrowest gap. This check is seldom possible with ball bearings.

4.1.7 Separable bearings, such as the cylindrical roller types and others, usually have their outer rings removed while the inner rings are being fitted. It is of the utmost importance to see that these outer rings do not get mixed up, and that each one goes back to its original mating inner ring otherwise the diametric slackness may be greatly altered. An outer ring shall be replaced in position without the use of force, being slightly rotated in the process to facilitate moving it into position. Use of force may scratch or dent both rollers and tracks.

4.1.8 An adapter-sleeve mounting (*see* Fig. 4) is an easy method of securing a rolling bearing to a shaft without shoulders, but careful fitting is necessary. The following procedure is recommended:

a) Wipe the shaft.

b) Wipe the inside and outside of the sleeve.

c) Apply a trace of light oil to shaft and sleeve with a clean rag.

d) Arrange the component parts on the shaft so that the adapter nut tightens up in the direction opposite to that in which the shaft

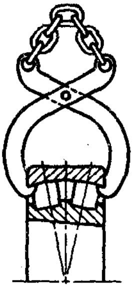


FIG. 3

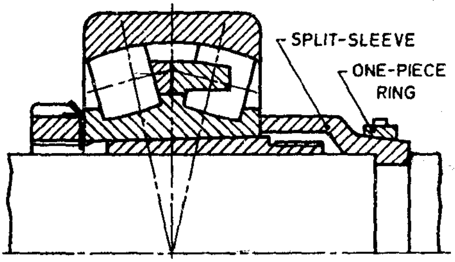


FIG. 4

rotates. This is always advisable, if the nut is not provided with a locking device.

e) Where a bearing should be positioned accurately in relation to other shaft fittings, the auxiliary split sleeve is of assistance. When the bearing has been fitted, the auxiliary sleeve is removed.

f) The adapter sleeve may be moved along the shaft most easily without the bearing, and the operation is facilitated by opening up the sleeve slightly with the point of a screw driver inserted in the slit.

g) By exerting finger pressure between the large end of the sleeve and the bearing inner ring, force the two together until the sleeve grips the shaft, then drive the bearing further on to the sleeve by light blows on hardwood drift, directed against various positions around the inner ring face, until the correct fit is obtained. Finally, place the lock-washer (if any) in position, tighten up the nut, and lock for security.

h) In the last operation, guard against expanding the inner ring unduly, since the rolling elements in consequence might become jammed or the ring fractured. On the other hand, if the fit is too light the inner ring may loosen up in service and trouble may ensue. The bearing should rotate freely after fitting, and if it is of the self aligning type, its outer ring should lend itself to swivelling in any direction.

j) After the bearing has been in operation, the nut may be tightened up slightly to take up any looseness in the fit that may have developed.

4.1.9 If a loose fit, sliding fit, or easy fit is specified without precise information about the shaft limits, it is well to remember that on a hardened and ground seating, ring creep has a less detrimental effect than on a soft and roughly finished one, but the looser the fit, the greater the shake and a rattling fit is not desirable. Loose fits for shaft seatings are to be specified where axial adjustment of the inner ring has to be made or allowed for.

4.1.10 If the shaft rotates, the fit should be no slacker than absolutely necessary. If the shaft does not rotate, or the load is stationary, a slackfit is of less consequence, but even then excessive play is undesirable. Distance sleeves, if used, shall slide freely on the shaft.

4.1.11 The fit of the rotating ring of a thrust bearing on the shaft is not quite so important as the corresponding fit for a radial bearing, as there is less tendency for the thrust ring to creep when the complete bearing is fitted square with the shaft axis. Nevertheless an interference fit is preferable. The sleeves of a double-acting thrust bearing shall have a close sliding fit.

4.2 Housings

4.2.0 Bearings are usually fitted in their housings after being placed on the shaft. The precise manner of introduction of bearings depends largely on the housing design, the position of other bearings and the character of the fit, and on whether the shaft is horizontal or vertical. The following suggestions may readily be adopted to suit different circumstances.

4.2.1 If the outer ring of a radial bearing has to be adjusted axially, the shaft shall be slowly rotated during the adjustment. As soon as noticeable resistance to rotation is felt, the rotation should be stopped, and the adjusting screws turned back slightly to ensure free running. This procedure is not to be followed if the bearings are preloaded.

4.2.2 If the fit of an outer ring proves to be too tight and scraping is resorted to, this shall be done very carefully to avoid making the seating oval. With split housings it is bad practice to use shims at the joint for the purpose of obtaining a looser fit. If felt washers are cut at the joints, their ends shall not protrude into the joint. It should not be possible to put the cap of a housing the wrong way round, but if it is, it shall be ensured that it mates with the lower half correctly. Housing parts shall not be mixed, as it is unlikely that they are completely interchangeable.

4.2.3 Where a fit is looser than specified, no attempt shall be made to correct it by inserting pieces of paper, tinfoil, etc, or by using grub-screws to grip the outer rings. The housing may be corrected by metal-spraying its bore or boring it out slightly and fitting a liner, after which remachining to size is necessary in both the cases.

4.2.4 Though the use of shims between a housing and its endcovers is not good practice, owing to the likelihood of shims becoming lost or mixed with others during repairs, their use on occasions may be justified. When a replacement bearing is fitted, new shims differing in thickness from the old ones may probably be required. Further points to be borne in mind are:

a) Housing bases shall be fitted on truly flat surfaces or they may fracture when the holding-down bolts are tightened.

b) Soft wood shall not be used for packing up housing or else the base fitting strips may dig into the wood.

c) Outer rings in split housings shall not be gripped when in a tilted position, otherwise severe distortion of the ring will result.

d) There shall be no rubbing between adjacent faces of labyrinth seal or other metal parts. This usually results in excessive temperature rise.

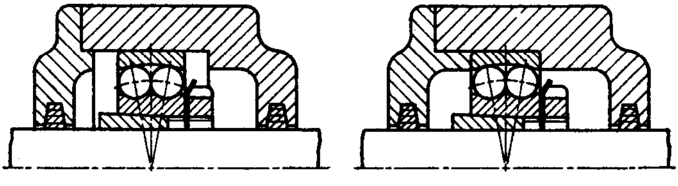
e) Misalignment of the halves of flanged couplings cause heavy radial or axial load or both.

f) Expansion couplings which do not respond to shaft contraction or expansion, may cause excessive thrust load.

g) Only one bearing on a shaft, that is the 'locating' bearing, as a rule has both inner and outer rings secured axially for the purpose of shaft location (*see* Fig. 5). All other bearings ('free' bearings) on the shaft shall be free to move axially in their housings when the shaft expands or contracts.

   An exception is made when two bearings are comparatively close together (*see* Fig. 6), or when a cylindrical-roller bearing outer ring without thrust flanges has to be held endwise.

h) With a tight-fitting outer ring, it is specially important to ensure that it takes up its correct position in relation to its inner ring, otherwise heavy end-thrust and other detrimental effects may result.



FREE BEARING

LOCATING BEARING

Fig. 5

4.2.5 The use of mild steel tube with an end cap for driving a tight fitting outer ring into position is illustrated in Fig. 7. The inner face of

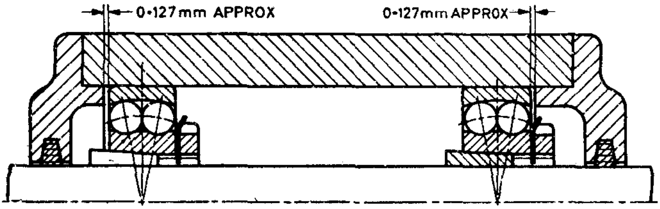


Fig. 6

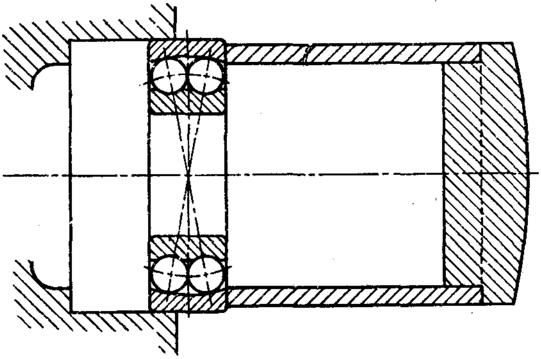


Fig. 7

the tube shall be held flat against the outer-ring face and the cap hit squarely.

4.2.6 Where an inner ring is already fitted to its shaft, a tool of the kind shown in Fig. 8 is of great help in driving a tight-fitting outer ring into place. Both annular surfaces of the tool are in the same plane and shall make simultaneous contact with both rings, the transmission of shock loads to the tracks through the balls being thus avoided, the same kind of tool may be employed as shown in Fig. 9, when the bearing has first been fitted into its housing and the inner ring is afterwards driven on to its shaft.

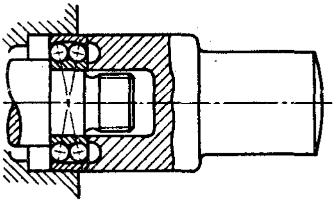


Fig. 8

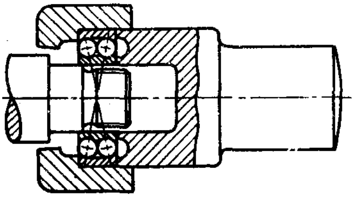


Fig. 9

4.2.7 If a pulley, coupling, or other part has to be driven into position on the shaft after the bearings have been fitted, the free end of the shaft shall be held against a rigid support as shown in Fig. 10 to avoid transmission of the shocks caused by hammer blows to the bearings.

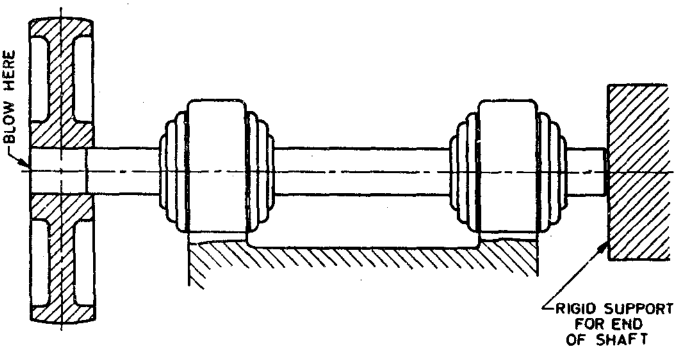


FIG. 10

5. TRIAL RUNS

5.1 All rotating parts shall first be turned slowly by hand, individually and collectively, to ascertain if there is undue resistance anywhere. The bearings shall be adequately lubricated before running at speed, even for a short time, and it is a good plan and is essential in most cases to make certain the lubricant has reached every part. There is no difficulty with oil in this respect but where grease is used it shall be pressed between the interstices of the cage and rolling elements by hand, the bearing being rotated slowly to assist penetration. While the machine is running, the character of the sound from each bearing provides a good indication whether all is well or not.

5.2 A well-tried and useful way of isolating the sound from each bearing is to place the ear against one end of a short piece of wood, screw driver or the like and the other end against the bearing housing, or some form of amplifying stethoscope may be used. Housings should also be felt with the hand to discover if there is any undue rise in temperature. Some information as a guide for such tests is given below:

Sl No.	*Sound*	*Cause*	*Remedy*
1	Metallic note	Bearing dry	Clean the bearing and housing thoroughly, and re-lubricate
2	Pronounced low note	Track indentations	Fit new bearings
3	Irregular	Foreign matter	As for 1

Sl No.	*Sound*	*Cause*	*Remedy*
4	Harsh	Tracks pitted or flaked	As for 2
5	Knocking	Rolling elements damaged or cracked ring	As for 2
6	Rumbling	a) Fluted tracks, due to vibration	As for 2
		b) Fluted tracks due to electric arcing	Fit new bearings and check electric insulation

7 Abnormal temperature rise can occur with bearings in all states from the new condition to that of breakdown. Apart from damage to the bearing itself, the cause may be excessive lubricant, an inadequacy of heat-radiating housing-surfaces, too stiff a grease, too heavy an oil, too high speeds, too great loads or too tight fits.

6. PROTECTION OF BEARINGS IN MACHINES WHILE BEING TRANSPORTED

6.1 Most greases set up slight corrossive or electrolytic action, where the rolling elements are in contact with the tracks and the bearings are stationary for a few months. In general, this action can be ignored, but if it is known that a machine will be stored for six months or more after erection, the procedure outlined below is advisable:

- a) When fitting the bearings, their protective coatings should not be removed;
- b) If only a very short test of the machine is to be made, further lubricant should not be added until the test is completed;
- c) After the test, pure vaseline is pressed into the bearing so that it reaches all the surfaces;
- d) The housing is then packed with the grease required, for normal operation, to the usual height; and
- e) Further running of the machine shall be avoided until it is put into service.

6.2 Bearing protection during the short period between the complete assembly of a machine and the commencement of operation at its final destination shall also be provided for.

6.3 Where grease is used, a normal charge will doubtless have been given to each bearing during assembly, in which event no further attention is necessary, provided the machine is adequately covered during transit. Where oil is the lubricant the bearing will have received a protective coating during the trial run, and this can generally be relied upon for a week or two. When longer period is involved, a coating of pure vaseline shall be applied, and instructions given to have this washed out later if necessary.

6.4 Vibration set up by jolting during transport is a more common cause of tracks indentation than is generally realised. When the bearing slackness is greater than the normal, the tracks are most likely to be indented from this cause; and consequently to acquire the resulting characteristic marking.

6.5 In cases where a machine is dismantled prior to despatch, the same care shall be taken in repacking the bearings as was originally taken by the manufacturer and precautions against the entry of sawdust, shavings, etc, into the housings are advisable, for there may be poor facilities for washing and cleaning where the machine will be reassembled.

7. MAINTENANCE

7.1 The most important elements of successful and economic maintenance of rolling bearings, are the periodical replenishing of lubricant and charging it completely at less frequent intervals. Some kind of record should be kept, since this is of great value for reference when it has to be decided whether the intervals may be lengthened or sometimes shortened.

7.1.1 It is advisable every time the lubricant is replenished to examine all the lubrication arrangements thoroughly to ascertain whether they are functioning as expected, and at the same time to examine the lubricant itself. Hardening or soiling of grease and charring of oil, point to some kind of trouble, which shall be set right at once.

7.1.2 Leakage of grease or oil from housing joints or through the seals is also an indication that something is wrong. The seals have possibly become inefficient through wear of felt washers, if used; or there may have been rubbing and wear of the labyrinth surfaces due to some constructional fault. Where grease seals are faultless, leakage may be due to disintegration of the grease, the free oil escaping through seals, not designed for retaining oil. This condition shall be remedied at once, since it means that the grease is faulty or that the temperature has been sufficiently high to melt it.

7.1.3 When removing old grease, a thin hardwood scoop may be used, as it is less likely to scratch the rolling elements than a metal one. If the grease has hardened, benzine and not paraffin shall be used for cleaning. A small quantity of benzine is put into the lower half of the casing, allowed to soak for a few minutes, and then sponged out with a non-fluffy rag. When the bulk of the grease has been removed, some more fresh benzine is put in, the shaft is slowly turned, to allow the benzine to reach every part of the bearing. In bad cases, it is better to remove the housing completely, so as to enable bearing and housing to be treated separately.

7.1.4 The grease-can should be kept covered when not in use.

7.2 Repairs

7.2.0 Correct selection, fitting, and maintenance, together with correct housing design, ensure a satisfactory life for any rolling bearing, but eventually there comes a time when, for one reason or other; it may be fatigue, abuse or dismantling a machine for reasons not directly connected with the bearing, the bearing has to be removed from its seating. When the bearing is still in a good condition or is to be submitted for expert examination, the removal shall be executed as carefully as the original fitting was.

7.2.1 Indentation shall be avoided, grease shall not be wiped off, dirt or swarf shall not be picked up, and the bearing shall be wrapped in grease proof paper and properly placed in a box if it has to be sent away. Samples of grease shall not be carried in cardboard boxes, as they absorb oil from the grease, thus making an analysis valueless.

7.2.2 Before dismantling bearings and associated parts, the fitter shall study arrangement drawings of the machine in order to discover the best procedure unless clear instructions have already been issued. All dismantled parts should be so arranged or marked that there shall be no doubt as to how the parts have to be reassembled.

7.2.3 Removal without damage to the bearings may be effected in various ways, depending on the bearing fit and the position and dimensions of adjacent parts. The appliances and methods described are for use with tight fits.

7.3 Removal of Housing

7.3.1 A simple and effective means of withdrawing a housing is shown in Fig. 11. This method makes use of holes tapped in the housing wall

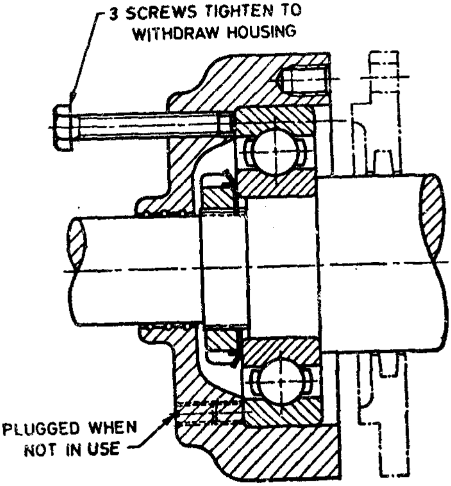


Fig. 11

before the bearing is fitted, the holes being closed by short screws until the withdrawal screws are required.

7.3.2 A method suitable for housing with through holes for end cover bolts is illustrated in Fig. 12. The important part here is the special nut, whose outer edge supports the bearing outer ring while the housing is being withdrawn. A cross-bar, with central screw for applying pressure pulls on the housing through the medium of the housing-cover bolts as shown; when the cross-bar is not available, a hammer and a piece of hardwood may be used without danger to the bearing.

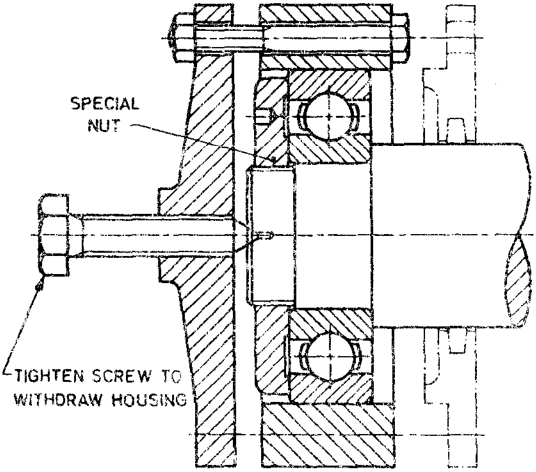


Fig. 12

7.3.3 In stubborn cases the fit may be loosened by heating the outside of the housing in some way, but there is always a risk of cracking the housing if the heating is not uniform all around. Too much time shall not be expended on this job, or heat may be conducted to the bearing ring, which may then expand together with the housing. A blow-lamp is the handiest source of heat, but is to be used very carefully.

7.4 Removal of Inner Rings

7.4.0 An inner ring is more easily fitted than withdrawn, when the fit is tight.

7.4.1 A hammer and drift may be used as shown in Fig. 13A when the shaft has two or three grooves in which the end of the drift can be placed, but there is a danger of slipping of the drift and, when the blows are heavy, of fracturing the thin tip of the ring.

7.4.2 Another method is indicated in Fig. 13B for use when the outer diameter of an inner ring is greater than the shaft-shoulder diameter. A short tube is placed between the ring and the drift, the ring being thus protected from the shock of the blows. The force of the blows is also better distributed. Where a whole tube cannot be got into position, a split tube with its two halves secured together temporarily by wire or even a half-tube only, may be employed. These are only suitable for relatively light press fits.

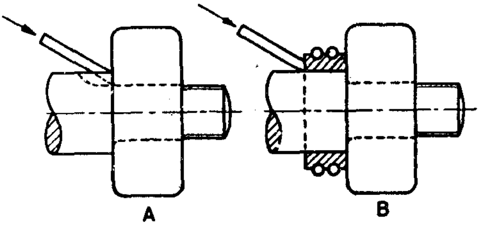


Fig 13

7.4.3 A more satisfactory method is to use a capped tube (*see* Fig. 14). Better still would be to put the shaft in a screw press with a split tube between the inner ring and the press table (*see* Fig. 15).

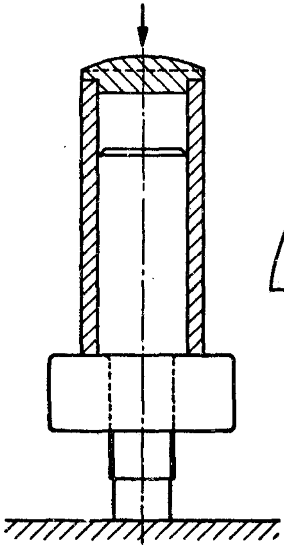


Fig. 14

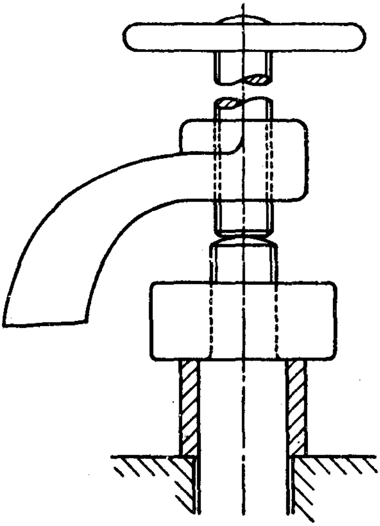


Fig. 15

7.4.4 A useful puller device is shown in Fig. 16, the back plate *A* being made in two parts, which are clamped together in position by bolts. The front plate *B* has a steel ball socketed between its screw and the shaft end, the effort required to turn the screw being thus reduced. In pullers for large bearings a ball thrust bearing may be used in place of the ball. For general use there shall be several pairs of holes in plates *A* and *B* to allow some adjustment. The housing and cover, if strong enough, may sometimes be utilized instead of the back plate *A*.

7.4.5 A special tool for withdrawing a self-aligning roller bearing inner ring, the outer ring and rollers having been removed first, is shown in Fig. 17. The two halves of the split ring which accurately conform

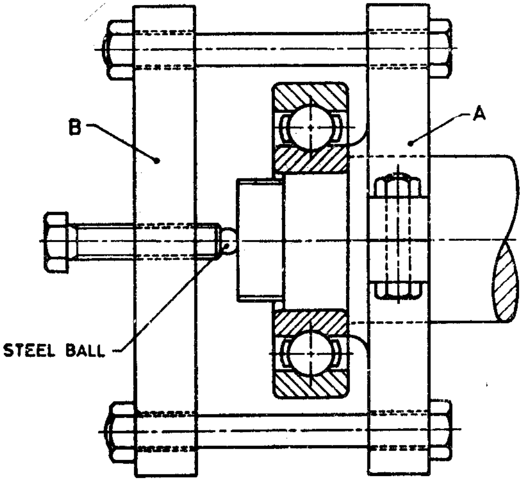


FIG. 16

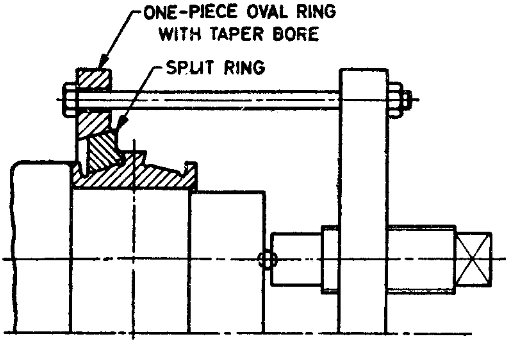


FIG. 17

internally to the curvature of the roller track shall make contact with each other at the joint, to prevent nipping the tracks. Conical surfaces on the outside of the split ring and on the inside of the back puller-plate engage to hold the parts of the split ring together, and at the same time transmit the withdrawal force to the central flange of the bearing ring.

7.4.6 To remove thin inner ring, such as those of needle-roller bearings, the puller shown in Fig. 18 will be particularly useful. It will be noted that provision shall be made in fixing the details of the bearing arrangement to allow the inner hook of the two T-shaped pieces to get behind the inner ring. These pieces fit into T-shaped slots in the puller tube and are held in place by the auxiliary ring shown.

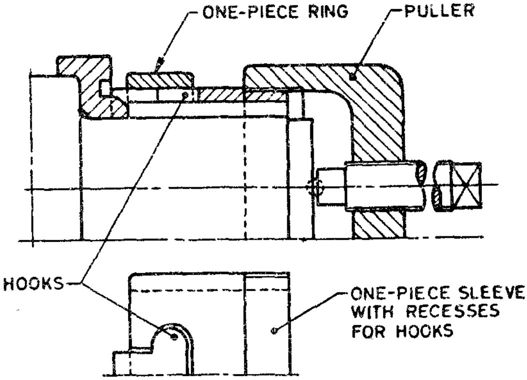


Fig. 18

7.4.7 In difficult cases it may be necessary to heat the inner ring to facilitate its removal. Fig. 19 shows a method of applying heat by means of steam issuing out of suitably placed holes in a curved pipe encircling the inner ring. Owing to the use of steam, the bearing shall be washed in white spirit immediately after its removal and then thoroughly regreased to prevent corrosion.

7.5 Cleaning Bearings

7.5.0 It is seldom necessary to clean bearings with the sole object of removing the rust preventive with which they are coated before being packed. Rust preventives with a petroleum-jelly base have certain lubricating qualities, and, in any case, since the amount used for the protection of bearing is small, no harm is done when they become mixed with the grease or oil used for lubrication. With small high-speed bearings, however, and a light oil or oilnist, as the lubricant, it may be justifiable to wash out the protective coating in order to prevent a possible initial rise in temperature due to its presence.

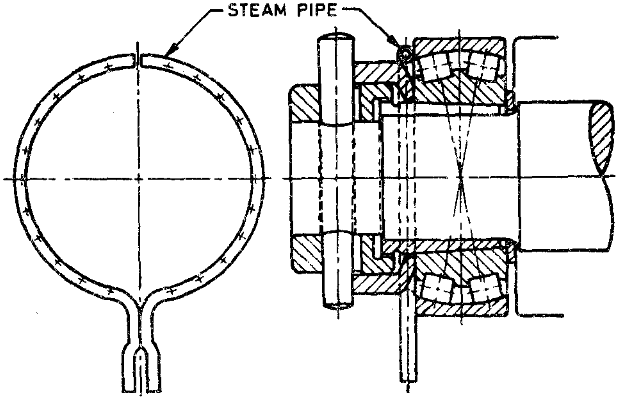


FIG. 19

7.5.1 As a rule washing shall only be resorted to when bearings have become dirty, or when the mechanism in which they are to be used is so sensitive that even slight irregular resistance to rotation is not permissible.

7.5.2 The choice of any particular combination of various cleaning agents, depends on the number of bearings to be cleaned, the kind of apparatus available and the risk of fire or fumes involved. The cleaning media most commonly used are:

a) petrol,
b) benzine,
c) benzol (commercial benzine),
d) white spirit (low flashpoint),
e) turpentine,
f) paraffin,
g) light spindle-oil,
h) trichloroethylene,
j) carbon tetrachloride,
k) alkaline solutions, and
m) compressed air.

Of these the first four are most suitable for general use. White spirit is generally preferred since it is less volatile, so that the loss by evaporation and risk of fire are minimized.

7.5.3 In order to render petrol, benzine and benzol less inflammable, they may be mixed in equal parts with good quality industrial

(non-coloured) methylated spirit without appreciably affecting their cleaning properties.

7.5.4 Turpentine is a good cleaner, though not so effective as benzol. It leaves a tar-like residue, which is difficult to remove from cage pockets and other inaccessible surfaces. In general turpentine cannot be recommended for the washing of rolling bearings.

7.5.5 Commercial paraffin is less effective than any of the first five liquids mentioned, and on account of its water content, tends to promote rusting. This effect may be obviated by mixing 1 to 2 percent lanoline or mineral oil with the paraffin. The resulting mixture is less harmful to the skin. In all cases the paraffin shall be free from acids.

7.5.6 Light spindle-oil is excellent if applied hot in the form of a jet. Its use obviates danger of corrosion, since the bearings are never in a dry state immediately after treatment, as is the case with most other agents.

7.5.7 Trichloroethylene and carbon tetrachloride are good degreasers, but leave surfaces so dry that they shall be oiled immediately, and the bearings shall not be touched by hand until this has been done. These cleaners do not remove carbonaceous matter. As trichloroethylene leaves a white deposit which tends to corrode the surfaces, all traces of this deposit shall be removed by thoroughly rinsing in oil. Both solvents are non-inflammable; but their vapours are dangerous if inhaled. Specially designed apparatus is necessary for their use.

7.5.8 Two to five percent hot soda solution or a three percent metasilicate solution may be used when nothing better is available. After this treatment, a washing in 2 percent soap solution helps temporarily to minimize corrosion. Steel parts so washed shall be rinsed with 0·1 percent boiling sodium nitrite solution; for cast iron parts 3 percent sodium nitrite solution is necessary. After the rinsing, bearings shall be dried by means of a jet of hot air, while they are slowly rotated, or by leaving them in an oven at 100°C for about 40 minutes. Immediately after drying suitable protection is necessary.

7.5.9 Compressed air may be used for dislodging loose particles of grit, provided that the air is dry. Usually, however, there is a certain amount of moisture in the air, and as this condenses when the air leaves the nozzle, precautions should be taken to exclude any possibility of rust formation.

7.5.10 After any cleaning process it is necessary to protect the bearing by dipping them in hot petroleum jelly or oil, or by applying thoroughly the grease to be used that it reaches every part of the surfaces. In the latter case rotation of bearings is necessary while the grease is being applied.

7.5.11 Solid particles cannot be removed by simply immersing bearings in a cleaning bath; some kind of gentle wiping or mechanical agitation is necessary. When only small numbers of bearings have to be washed, perhaps the best method is to employ two separate baths, for which anyone of the liquids (a) to (d) listed in **7.4.2** is suitable. The first bath is used for preliminary washing, and the second for the final washing.

7.5.12 In the first bath, each bearing is moved about vigorously, without rotating it, since any trapped foreign matter might scratch the tracks or rolling elements. After as much as possible of the dirt has been removed this way, the bearing is transferred to the second bath. It is now rotated, gently at first, then faster until all trace of grit has been removed. The bearing is removed from the bath, surplus liquid shaken off, dried and given a protective coating.

7.5.13 When it is desirable that the last vestige of entrapped dust shall be removed, the condition envisaged can be approached by lightly fixing the inner ring of the bearing on the top end of a vertical spindle and then running the spindle at 1 000 to 3 000 rev/min and directing a fine jet of white spirit on the cage and the balls. The outer ring lags behind the inner, owing to the retarding effect of the jet, but the difference in speed is not so great as to give rise to any danger of scratched surfaces before the loose particles are dislodged. A suitable shield around the spindle is necessary to catch the spray, and a filter and collector should be added to clean and retrieve the used spirit.

7.5.14 The simplest and safest method is to apply a jet of hot light spindle-oil direct to the bearing. As the process is a bit messy, an enclosed cabinet with a window and with openings for the hands is necessary. The bearings may be laid flat on a perforated or corrugated tray, and the jet sprayed over them, it is better to place them on the top ends of stationary and vertical spindles and direct a jet on to the cage and balls so that it will cause rotation of the bearings.

7.6 Extreme Pressure Lubricants

7.6.1 These are to be used in gear boxes where the gear-tooth specific loads are high. They protect the tooth surfaces by depositing a thin protecting film under pressure. The same lubricant is often used to lubricate the bearings, on which a similar film is also deposited. Discoloration of the tracks by this film shall not be confused with discoloration due to other causes. This film has been found to be harmless by experiments so far conducted.

7.7 Bearing Repairs

7.7.0 It is often more economical to go in for a brand new bearing than go to the expense of repairing an old one, partly because of the initial uncertainty concerning what will be necessary, the process of disassembling the parts, examining, regrinding where required. Fitting new roll elements and cages, does not lend itself to routine methods, and may well cost more than all the processes necessary to produce a new bearing.

7.7.1 Fatigue effects are not confined to surface material, but penetrate to some depth, so that merely grinding away surface blemishes cannot give a worn bearing an entirely new lease of life. Large and expensive bearings, however, are often worth the trouble of repairing, particularly when the damage is superficial, or when any wear that has taken place is due to abrasive action only. A fractured ring can often be replaced if other parts are undamaged.

7.7.2 Rolling elements are graded in groups with exceedingly fine tolerances, and only elements from the same group should be used in any one bearing. Putting in a ball or roller which is smaller or greater in diameter than the others will seriously jeopardise the remainder of the bearing's life.

7.7.3 Where the bore of a bearing is badly worn owing to creep or abrasive action, regrinding is possible but renders the bearing non-standard and may thus cause difficulty, in case replacement should become necessary later on. At the same time the shaft seating may also have suffered and may require re-turning or regrinding. To restore the original fit, it is necessary to enlarge the shaft seating or reduce the bearing bore or both, by chromium or nickel plating the surfaces, metal spraying or fitting a sleeve and grinding to size. To take a sleeve of sufficient sectional depth, the shaft needs further reduction. This shall not be permitted, where the shaft is already weak.

7.7.4 Innumerable bearings are discarded because of apparently excessive diametric slackness, although many of them are capable of further efficient service. It is difficult to judge slackness by moving bearing rings by hand radially, axially, or angularly, in relation to each other. Special measuring devices are essential for obtaining reliable values.

7.7.5 A common way of checking slackness in single-row rigid ball bearings is to rock the outer ring side ways in relation to the inner ring. This method gives an approximate notion of the actual slackness, if the movement obtained is compared with that of two other bearings of the same type and size, one having the maximum permissible slackness and the other the minimum. Excessive wear may be detected in this manner.

7.7.6 The checking of radial slackness in roller bearings by feeler gauges has already been described in **4.1.6**.

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